Chapter 1
Operational Procedures

1.1 GENERAL

The Joint Typhoon Warning Center (JTWC) provides a variety of products and services to qualified organizations for the area of responsibility (AOR) described by USCINCPACINST 3140.1W. The following products are routinely issued by JTWC.

1.1.1 SIGNIFICANT TROPICAL WEATHER ADVISORY

Issued routinely once every 24 hours, or more frequently as needed, to describe all tropical disturbances and their potential for development into a significant tropical cyclone during the advisory period. Separate advisories are issued for the Western Pacific and the Indian Ocean.

1.1.2 TROPICAL CYCLONE FORMATION ALERT

Issued as conditions warrant and are intended to notify customers when a tropical disturbance is expected to develop into a significant tropical cyclone within 24 hours.

1.1.3 TROPICAL CYCLONE WARNING

Issued either at 6 hourly or 12 hourly intervals and provides forecasts of position, intensity, and wind distribution.

1.1.4 PROGNOSTIC REASONING MESSAGE

Issued in conjunction with tropical cyclone warnings in the North West Pacific (NWP). This message provides Meteorologists with the rationale for the intensity, movement and wind distribution contained in the JTWC warning.

1.1.5 PRODUCT CHANGES

The contents and availability of JTWC products and services are set forth in USCINCPACINST 3140.1W. Changes to USCINCPACINST 3140.1W are discussed and approved at the annual U.S. Pacific Command (PACOM) Tropical Cyclone Conference.

1.2 DATA SOURCES

1.2.1 COMPUTER PRODUCTS

Numerical and statistical guidance are provided to JTWC by Fleet Numerical Meteorology and Oceanography Center (FLENUMETOCCEN, or FNMOC) at Monterey, California. FNMOC also supplies JTWC with numerical analyses and prognoses from the Navy Operational Global Atmospheric Prediction System (NOGAPS) via the DOD NIPRNET network (Internet gateway). FNMOC furthermore, provides JTWC with numerical analyses and prognoses from the (U.S.) National Center for Environmental Prediction (NCEP), the European Centre for Medium-Range Weather Forecasts (ECMWF), and the Australian Meteorological Bureau.

1.2.2 CONVENTIONAL DATA

These data sets are comprised of land and ship surface observations, observations from commercial and military aircraft (AIREPS) recorded within six hours of synoptic times, and cloud-motion winds derived from satellite data. The data is computer plotted, and manually analyzed for the surface/gradient and 200-mb levels twice daily, at the 00Z and 12Z synoptic times.

1.2.3 SATELLITE RECONNAISSANCE

Meteorological satellite imagery is obtained from the Defense Meteorological Satellite Program (DMSP), National Oceanographic and Atmospheric Administration (NOAA), and other sources. Satellite reconnaissance is discussed further in Section 2.3, Satellite Reconnaissance Summary. In addition to visual, infrared and water vapor imagery, microwave data from DMSP and European Remote Sensing (ERS)-2 satellites provide additional information on tropical cyclone location and the distribution of low-level winds.

1.2.4 RADAR RECONNAISSANCE

When a well-defined TC moves within range of land-based radar sites, radar reports are invaluable for determination of position, movement, and, in the case of Doppler radar, storm structure and wind information. JTWC's use of radar reports during 1998 is described in Section 2.4, Radar Reconnaissance Summary.

1.2.5 AIRCRAFT RECONNAISSANCE

No aircraft fixes were available in 1998.

1.2.6 DRIFTING METEOROLOGICAL BUOYS

In 1998, 30 drifting buoys were deployed in the NWP by Air National Guard C-130 aircraft under the auspices of NAVOCEANO in support of JTWC. This buoy deployment is part of a continuing Commander, Naval Meteorology and Oceanography Command (COMNAVMETOCCOM) Integrated Drifting Buoy Plan support effort implemented to meet CINCPACFLT tropical cyclone warning support requirements.

Of the 30 buoys, 24 were Compact Meteorological and Oceanographic Drifters (CMOD) with temperature and pressure sensors and six were Wind Speed and Direction (WSD) buoys which measured windspeed and direction, temperature and pressure. Both type buoys were used in two deployments; one in June and another in September. The purpose of the two deployments was to overlap the expected three-month life-span of the CMOD buoys to provide continuous buoy coverage during the peak of the NWP Ocean tropical cyclone season.

1.2.7 AUTOMATED METEOROLOGICAL OBSERVING STATION (AMOS)

Through a cooperative effort between COMNAVMETOCCOM, the Department of the Interior, and NOAA/NWS to increase data availability for tropical analysis and forecasting, a network of AMOS stations has been installed in Micronesia. Table 1-1 provides a summary of the current AMOS configuration.

NWS Pacific Region (NWSPR) made a decision in mid FY 98 to discontinue deployment and maintenance of Coastal-Marine Automated Network (C-MAN) equipment procured from the NWS National Data Buoy Center for AMOS. This decision was based on the fact that the existing equipment was outdated, required extensive retrofit/refurbishing, and was too hardware and labor intensive to continue support for operations in remote Pacific island environments.

The NWSPR has had many years of experience with the installation and maintenance of Handar manufactured meteorological and tidal stations, which, although they do not provide the redundancy in sensors and communications capability, do function extremely well in remote tropical island environments.

Two AMOS sites, Kosrae and Enewetak were converted from C-MAN to Handar equipment in 1998. NWSPR plans for 1999 are to convert 3 AMOS sites (Pagan, Ngulu and Ulithi) to Handar and install a new AMOS site at Sorol Atoll, Federated States of Micronesia, if resources permit. Lack of affordable transportation to these remote locations has been and continues to be the limiting factor in a more speedy installation effort.

1.3 TELECOMMUNICATIONS

Primary telecommunications support for the Naval Pacific Meteorology and Oceanography Center/Joint Typhoon Warning Center (NPMOC/JTWC) is provided by the Naval Computer and Telecommunications Station (NCTS).

1.3.1 AUTOMATED DIGITAL NETWORK (AUTODIN)

AUTODIN is the primary medium for disseminating JTWC products to DOD customers. AUTODIN messages are also relayed via commercial telecommunications routes for delivery to non-DOD users.

1.3.2 AUTOMATED WEATHER NETWORK (AWN)

The AWN provides DOD and WMO weather data for in-house analysis and is also used to transmit JTWC products to DOD and U. S. government users. JTWC's AWN station identifier is PGTW.

1.3.3 AUTOMATED WEATHER DISTRIBUTION SYSTEM (AWDS)

The AWDS consists of two dual-monitor workstations which communicate with a UNIX based communications/data server via a private Local Area Network (LAN). The server's data connectivity is provided by two

Table 1-1 Automated Meteorological Observing Station Summary

Station ID	Site Name	Site Lo	cation	Installed	Status
REPUBLIC OF THE MARSHALL ISLANDS					
1. 91442	Ebon Atoll	4.60N,	168.70E	07/96	Partially functional
2. 91251	Enewetak Atoll	11.43N,	162.35E	11/89	Handar installed 1998
3. 91374	Maloelap Atoll	8.70N,	171.20E	08/96	Fully functional
4. 91377	Mili Atoll	6.10N,	172.10E	12/90	Partially functional
5. 91365	Ujae Atoll	8.93N,	165.75E	11/89	Not functioning (Destroyed by TY Gay, 1992)
FEDERATED STATES OF MICRONESIA					
6. 91411	Ngulu Atoll	8.30N,	137.50E	10/95	Partially functional (Handar planned for 1999)
7. 91343	Oroluk	7.63N,	155.16E	07/91	Partially functional
8. 91352	Pingelap	6.21N,	160.70E	09/91	Partially functional
9. 91355	Kosrae	5.36N,	162.96E	09/90	Handar 1998
10. 91338	Satawan	5.28N,	153.65E	03/93	Not functional
11. 91204	Ulithi	9.90N,	139.70E	11/95	Partially functional (Handar planned for 1999)
12. 91328	Ulul Atoll	8.60N,	149.67E	03/92	Fully functional
COMMONWEALTH OF THE N. MARIANA ISLANDS					
13. 91222	Pagan Island	18.13N,	145.77E	06/90	Not functional (Handar planned for 1999)
14.	Sorol Atoll				Planned 1999

dedicated long-haul data circuits. The AWDS provides JTWC with additional transmit and receive access to alphanumeric AWN data at Tinker AFB using a dedicated 9.6 kb/sec circuit. Access to satellite imagery and computer graphics from Air Force Weather Agency (AFWA) is provided by another dedicated 9.6 kb/sec circuit. The current configuration of AWDS was upgraded in 1996 to include improved workstation performance, and integration into NPMOCW's LAN backbone, this has access to the Defense Information Systems Network's (DISN), Non-secure Internet Protocol (IP) Router Network's (NIPRNET) Wide Area Network (WAN). The LAN and WAN connectivity allow JTWC to send and receive products among other AWDS. This system will be installed during 1999 at Pearl Harbor.

1.3.4 DEFENSE SWITCHED NETWORK (DSN)

DSN is a worldwide, general purpose, switched telecommunications network for the DOD. The network provides a voice and data link by which JTWC communicates TC information with DOD installations and civilian agencies. JTWC utilizes DSN for all switched voice and data. The telephone numbers for JTWC are DSN 474-2320 or Commercial (808) 474-2320.

1.3.5 NIPRNET/SIPRNET

The DOD unclassified TCP/IP based NIPRNET network and the classified Secret IP Router Network (SIPRNET) are routinely utilized to obtain meteorological and operational information that is vital to

JTWC. These networks are further used to disseminate tropical cyclone information. JTWC's unclassified NIPRNET web site address is http://www.npmoc.navy.mil./jtwc.html

1.3.6 TELEPHONE FACSIMILE (TELEFAX)

TELEFAX provides the capability to rapidly scan and transmit, or receive, documents over commercial telephone lines or DSN.

1.4 DATA DISPLAYS

1.4.1 AUTOMATED TROPICAL CYCLONE FORECAST (ATCF) SYSTEM

The UNIX based ATCF is the paramount system used by the Typhoon Duty Officer (TDO) in the preparation and dissemination of JTWC's products. Developed to automate the mundane and labor intensive tasks associated with tropical cyclone forecasting, ATCF can automatically display meteorological satellite fixes, working and objective best tracks, forecasts of track, intensity, and wind distribution, information from computer generated forecast aids, and products from other agencies. It also computes the statistics used and disseminated by JTWC.

1.4.2 NAVAL SATELLITE DISPLAY SYSTEM ENHANCED (NSDS-E)

NSDS-E is an implementation of the Terascan 3.0 software package developed by Seaspace. JTWC runs this package on three Sun workstations. It is used to process high resolution satellite imagery.

1.5 ANALYSES

The JTWC TDO routinely performs manual streamline analyses of composite surface/gradient-level (3000 ft (914 m)) and upper-tropospheric (centered on the 200-mb level) data for 00Z and 12Z daily. Computer analyses are conducted for other levels. Additional analyses and/or data plotting are conducted during periods of significant or unusual activity at intermediate synoptic times. Special products such as station-time plot diagrams, time-height cross-section charts and pressure-change charts are produced during these periods.

1.6 FORECAST PROCEDURES

This section discusses the Systematic and Integrated Approach to TC Track Forecasting by Carr and Elsberry (1994), referred to hereafter as the "Systematic Approach" and then provides JTWC's basic approach to track, intensity and wind radii forecasting.

1.6.1 THE SYSTEMATIC APPROACH

JTWC began applying the Systematic Approach (Figure 1-1) in 1994. The basic premise of this approach is that forecasters can improve upon dynamical track forecasts [guidance] generated by numerical models and other objective guidance if the forecasters are equipped with:

1) A meteorological knowledge base of conceptual models that organizes a wide array of scenarios into a relatively few recurring, dynamically-related situations; and

2) a knowledge base of numerical model tropical cyclone forecast traits and objective-aid traits within the different recurring situations that are organized around the meteorological knowledge base.

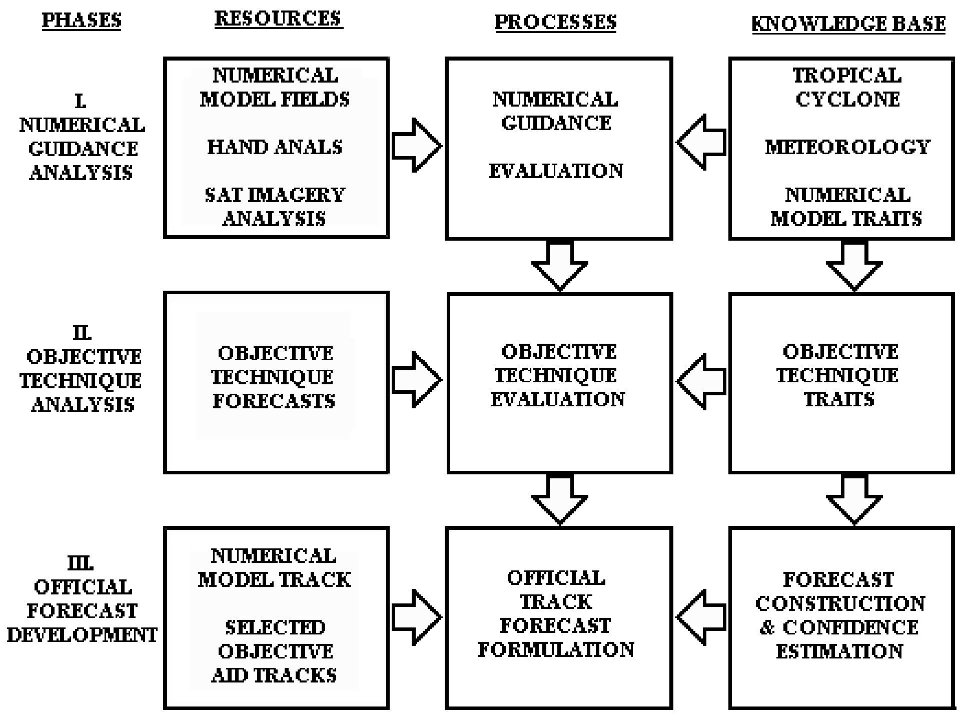

Figure 1-1. Systematic Approach Flowchart

1.6.1.1 General Concepts

Track, intensity, and size components of a TC forecast are dynamically interdependent.

1) TC motion affects intensity and how a TC intensifies can affect its motion.

2) TC size affects propagation relative to environmental steering. A large TC may significantly modify its environment. Thus, the present size of a TC and any subsequent changes in size can affect motion.

3) TC size may affect intensity indirectly through changes induced on TC motion.

1.6.1.2 Key Motion Concepts

TC motion results from a variety of causes.

1) Environmental Steering - To a first approximation, the TC vortex is advected by the winds of the large-scale environmental flow (i.e., the TC moves as a "cork in the stream").

2) TC Propagation - The motion of TCs usually departs in a minor, but not insignificant way from the large scale environmental steering vector.

3) TC-Environment Interaction - In certain situations, the circulation of the TC interacts with the environment in such a way as to significantly alter the structure of the environment, and thus modifies the steering vector that is the first-order effect on the motion of the TC.

1.6.1.3 Knowledge Base Framework

1.6.1.3.1 Environment Structure

Structure is classified in terms of a large-scale synoptic PATTERN and two or more synoptic REGIONS within the pattern that tend to produce characteristic directions and speeds of steering flow for a TC located therein. Five patterns with ten associated regions are recognized by the Systematic Approach. JTWC notes that not all TCs fit "neatly" into these patterns/regions at all times and that hybrids and transitions between patterns occur. These patterns/regions are briefly described below.

1.6.1.3.1.1 Patterns

There are five primary patterns:

1) STANDARD (S) (Figure 1-2)

   1) Most frequently occurring pattern in the NWP; and

   2) key feature is roughly zonally-oriented Subtropical Ridge (STR) anticyclones.

2) POLEWARD (P) (Figure 1-3)

   1) Second highest frequency of occurrence in the NWP;

   2) key feature is a ridge (anticyclone) that extends from the STR deep into the tropics and interrupts the tropical easterlies;

   3) usually has SW-to-NE axis orientation; and,

   4) usually produces strong poleward steering on its west and poleward side.

3) GYRE (G) (Figure 1-4)

   1) Only occurs during June-November period;

2) key feature is a particularly large and deep monsoonal circulation (thus, "monsoon gyre"); and,

3) usually situated between a zonally-oriented STR anticyclone to the NW and a meridionally-oriented anticyclone on its eastern periphery.

4) MULTIPLE (M) (Figure 1-5)

1) Key feature is more than one TC with a large break in the STR in the vicinity of the two TCs;

2) the TCs are oriented approximately east-west (i.e., zonally-oriented TCs);

3) the TCs must be far enough apart to preclude significant mutual advection, but close enough to preclude the development of ridging between them (typically greater than 10, but less than about 25);

4) the average latitude of the two TCs must be sufficiently close to the latitude of the STR axis (no more than about 10 equatorward or 5 poleward) so that regions of poleward/equatorward flow are established, which affect TC motion and intensification; and,

5) there are three subsets of the "M" pattern which describe varying degrees of interaction between the two cyclones.

5) HIGH AMPLITUDE (HA) (Figure 1-6) A newly identified pattern for the Southern Hemisphere. The key feature is a mid-latitude trough which penetrates very deeply into the tropics, almost to the equator. A combination of this trough and the subtropical ridge circulation to its east can produce long, southeastward oriented tracks. The ridge circulation to the west completes the pattern, by defining "Ridge Equatorward" and "Ridge Poleward" regions. A small area of "Equatorward Westerlies" is also defined.

1.6.1.3.1.2 Regions

There are ten primary regions associated with the four patterns:

EQUATORIAL WESTERLIES (EW) - The area of equatorial westerlies equatorward of the monsoon trough axis.

DOMINANT RIDGE (DR) - The area of tropical easterlies equatorward of the STR axis, except near any break in the STR.

WEAKENED RIDGE (WR) - The area of weaker southeasterly winds in the vicinity of a break in the STR.

MIDLATITUDE WESTERLIES (MW) - The area of eastward and poleward steering extending east from a break in the STR.

POLEWARD-ORIENTED (PO) - The area of poleward steering west of the ridge feature in the "P" and "G" Patterns

POLEWARD FLOW (PF) - Created in the vicinity of the eastern TC of a "M" Pattern as a result of the gradient between the western TC and the STR circulation to the east.

RIDGE POLEWARD (RP) - The poleward flow region of the HA pattern, where steering is provided by the western side of the anti-cyclone.

RIDGE EQUATORWARD (RE) - The equatorward flow region of the HA pattern, where steering is provided by the eastern side of the anti-cyclone.

TROUGH POLEWARD (TP) - The very long poleward flow region of the HA pattern, where steering is provided by the deeply penetrating mid-latitude trough.

EQUATORWARD FLOW (EF) - Created in the region of the western TC of a "M" Pattern as a result of the gradient between the eastern TC and the STR circulation to the west.

1.6.1.3.1.3 Nomenclature

JTWC makes routine use of the aforementioned Patterns and Regions of the Systematic Approach. In order to quickly transcribe this information, a short-hand contraction standard has developed. By utilizing the one-letter contraction of a pattern and the two-letter contraction of an associated region (e.g., S/DR), an effective method of quickly and accurately describing Systematic Approach concepts in writing exists.

1.6.1.3.2 TC Structure

TC structure consists of an INTENSITY that is based on the maximum wind speed near the center of the TC, and a SIZE that is based on some measure of the extent of the cyclonic wind component in the lower atmosphere. TC intensity is related to steering level and TC size is related to propagation and environment modification.

1.6.1.3.3 Transitional Mechanisms

These mechanisms act to change the structure of the environment (pattern/region) and fall into two categories:

1) TC-Environment Transformations. The TC and the environment may interact, resulting in a change in environmental structure (pattern/region) and thus the direction/speed of the associated steering flow. In addition, TC-environment transformations may result in a change to TC structure. Listed below are recognized TC-environment transformations:

- Beta Effect Propagation
- Vertical Wind Shear
- Ridge Modification by TC
- Monsoon Gyre-TC Interaction
- TC Interaction (Direct (DTI), Semi-direct (STI), and Indirect (ITI)) (Figure 1-7)

2) Environmental Effects. These also result in changes to the structure of the environment (pattern/region) surrounding the TC, but do not depend on, are or largely independent of, the presence of the TC. Recognized environmental effects are listed below:

- Advection by Environment

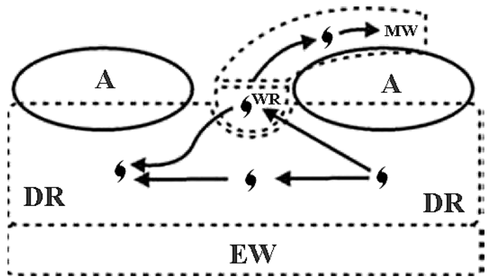

Figure 1-2. Standard Pattern

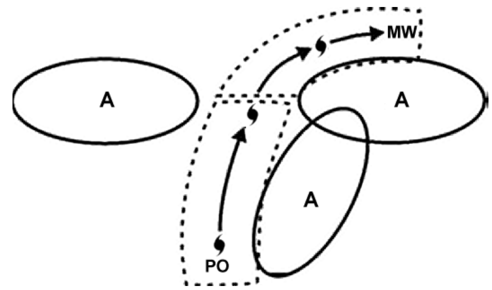

Figure 1-3. Poleward Pattern

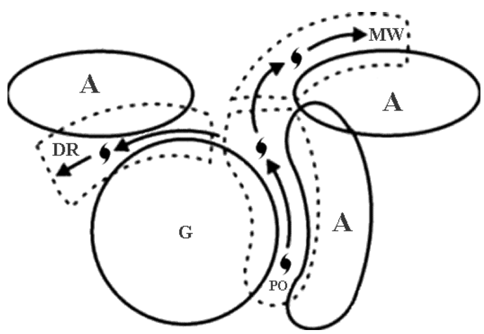

Figure 1-4. Gyre Pattern

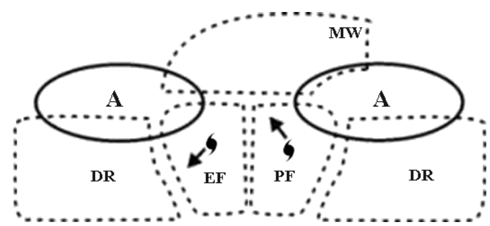

Figure 1-5. Multiple TC Pattern

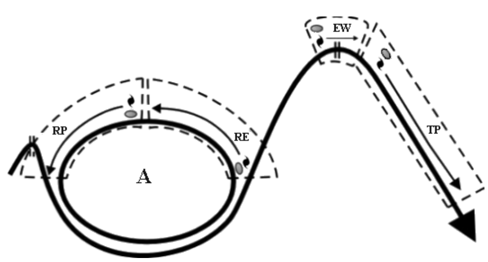

Figure 1-6 High Amplitude Pattern

LEGEND FOR FIGURES:

➔	= CHARACTERISTIC TC TRACK	PF	= POLEWARD FLOW
- -	= REGIONAL BOUNDARY	RP	= RIDGE POLEWARD
DR	= DOMINANT RIDGE	RE	= RIDGE EQUATORWARD
A	= ANTICYCLONE	PO	= POLEWARD ORIENTATED
MW	= MIDLATITUDE WESTERLIES	EW	= EQUATORIAL WESTERLIES
G	= GYRE	TP	= TROUGH POLEWARD
WR	= WEAKENED RIDGE	EF	= EQUATORIAL

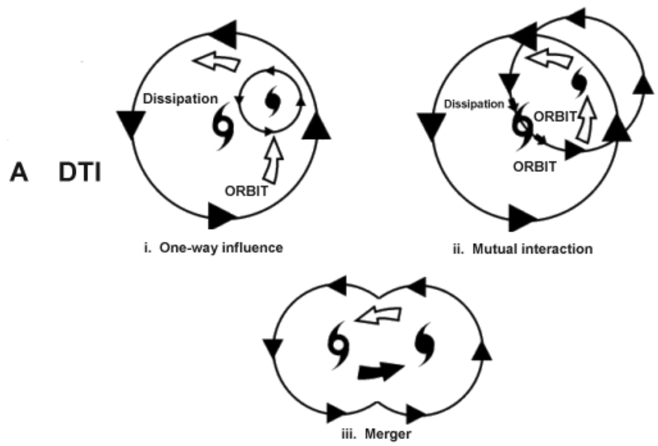

Figure 1-7a. Tropical Cyclone Interaction: (a) Direct TC Interaction (DTI) is composed of three types - (i) one way influence, (ii) mutual interaction, and (iii) merger.

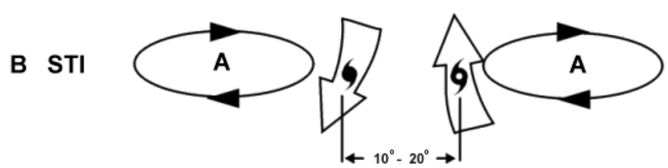

Figure 1-7b. Tropical Cyclone Interaction: Semi-Direct TC Interaction (STI).

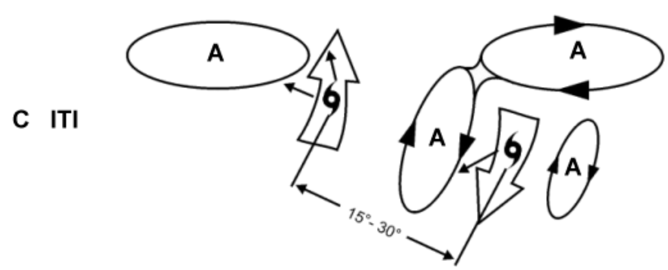

Figure 1-7c. Indirect TC Interaction (ITI).

- Monsoon Gyre Formation

- Monsoon Gyre Dissipation

Subtropical Ridge Modulation (by midlatitude troughs)

TC movement, intensification, and size evolution are closely linked, therefore, an "ideal TC forecast approach" may be defined as a fully integrated solution for the time evolution of the 3-dimensional three partial representations of the total TC circulation. TC track, intensity and size forecasts are then to be considered three partial representations of the total forecast solution.

1.6.2 BASIC APPROACH TO FORECASTING

1.6.2.1 Initial Positioning

The warning position is the best estimate of the center of the surface circulation at synoptic time. It is estimated from an analysis of all fix information received around that synoptic time. The analysis is aided by a computer-generated objective best-track scheme that weights fix information based on its statistical accuracy. The TDO includes synoptic observations and other information to adjust the position, testing consistency with the past direction, speed of movement and the influence of the different scales of motions. If the fix data are not available due to reconnaissance-platform malfunction or communication problems, or are considered unrepresentative, synoptic data and/or extrapolation from previous fixes are used.

1.6.2.2 Track Forecasting

In preparing the JTWC official forecast, the TDO evaluates a wide variety of information and employs Systematic Approach methodology. JTWC uses a standardized, three-phase TC motion-forecasting process to improve forecast accuracy and forecast-to-forecast consistency. Figure 1-1 depicts the three phases and inputs to the Systematic Approach outlined below.

1.6.2.2.1 Numerical Guidance Analysis Phase

NOGAPS analyses and prognoses at various levels are evaluated for position, development, and relevant synoptic features such as:

1) STR circulations;

2) midlatitude short/long-wave troughs and associated weaknesses in the STR;

3) monsoon surges;

4) cyclonic cells in the Tropical Upper-Tropospheric Trough (TUTT);

5) other TCs;

6) the distribution of sea-surface temperature.

The TDO determines into which pattern/region the TC falls, and what environmental influences and transitional mechanisms are indicated in the model fields. The process outlined above permits the TDO to develop an initial impression of the environmental steering influences to which the TC is, and will be, subjected to as depicted by NOGAPS. The NOGAPS analyses are then compared to the manually-plotted and analyzed charts prepared by JTWC and to the latest satellite imagery, in order to determine how well the NOGAPS-initialization process has conformed to the available synoptic data, and how well the resultant analysis fields agree with the synoptic situation inferred from the imagery. Finally, the TDO compares both the computer and manually-analyzed charts to monthly climatology in order to make a preliminary determination of to what degree the TC is, and will continue to be, subject to a climatological or non-climatological synoptic environment. Noting latitudinal and longitudinal displacements of STR and long-wave mid-latitude features is of particular importance, and will partially determine the relative weights given to climatologically or dynamically-based objective forecast guidance.

1.6.2.2.2 Objective Techniques Analysis Phase

By applying the systematic guidance with the NOGAPS model prognoses and real world conditions, performance characteristics for many of the objective techniques within the synoptic patterns/regions outlined in Section 1.6.1.3.1.1 have been determined. Estimating the likely biases of each of the objective-technique forecasts of TC track, intensity, and size given the current meteorological situation, the TDO eliminates those which are most likely inappropriate. The TDO also determines the degree to which the current situation is considered to be, and will continue to be, climatological by comparing the forecasts of the climatology-based objective techniques, dynamically-based techniques, and past motion of the present storm. Additionally, the spread of the set of objective forecasts, when plotted, is used to provide a measure of the predictability of subsequent motion, and the advisability of including a moderate-probability alternate forecast scenario in the prognostic reasoning message or warning (outside the western North Pacific). The directional spread of the plotted objective techniques is typically small well-before or well-after recurvature (providing high forecast confidence), and is typically large near the decision point of recurvature or non-recurvature, or during a quasi-stationary or erratic-movement phase. A large spread increases the likelihood of alternate forecast scenarios.

1.6.2.2.3 Forecast Development Phase

The TDO then constructs the JTWC official forecast giving due consideration to:

1) Interpretation of the TC-environment scenario depicted by numerical model guidance;

2) known properties of individual objective techniques given the present synoptic situation or geographic location;

3) the extent to which the synoptic situation is, and is expected to remain, climatological; and,

4) past statistical performance of the various objective techniques on the current storm.

The following guidance for weighting the objective techniques is applied:

1) Weight persistence strongly in the first 12 to 24 hours of the forecast period;

2) use conceptual models of recurring, dynamically-related meteorological patterns with the traits of the numerical and objective-aid guidance associated with the specific synoptic situation; and

3) give significant weight to the last JTWC forecast at all forecast times, unless there is significant evidence to warrant departure (also consider the latest forecasts from regional warning centers, as applicable).

1.6.3 INTENSITY FORECASTING

The empirically derived Dvorak (1984) technique is used as a first estimate for the intensity forecast. The TDO then adjusts the forecast after evaluating climatology and the synoptic situation. An interactive conditional-climatology scheme allows the TDO to define a situation similar to the system being forecast in terms of location, time of year, current intensity, and intensity trend. Synoptic influences such as the location of major troughs and ridges, and the position and intensity of the TUTT all play a large part in intensifying or weakening a TC. JTWC incorporates a checklist into the intensity-forecast procedure. Such criteria as upper-level outflow patterns, neutral points, sea-surface temperatures, enhanced monsoonal or cross-equatorial flow, and vertical wind shear are evaluated for their tendency to enhance or inhibit normal development, and are incorporated into the intensity-forecast process. In addition to climatology and synoptic influences, the first estimate is modified for interactions with land, with other tropical cyclones, and with extratropical features. Climatological and statistical methods are also used to assess the potential for rapid intensification.

1.6.4 WIND-RADII FORECASTING

The determination of wind-radii forecasts is a three-step process:

1) Low-level satellite drift winds, scatterometer and microwave imager 35-kt (18 m/s) wind speed analysis (see Chapter 2), and synoptic data are used to derive the current wind distribution.

2) The first estimate of the radii is then determined from statistically-derived empirical wind-radii models. The JTWC currently uses three models: the Tsui model, the Huntley model, and the Martin-Holland model. The latter model uses satellite-derived parameters to determine the size and shape of the wind profile associated with a particular tropical cyclone. The Martin-Holland model also incorporates latitude and speed of motion to produce an asymmetrical wind distribution. These models provide wind-distribution analyses and forecasts that are primarily influenced by the intensity forecasts. The analyses are then adjusted based on the actual analysis from step 1, and the forecasts are adjusted appropriately.

3) Synoptic considerations, such as the interaction of the cyclone with mid-latitude high pressure cells, are used to fine-tune the forecast wind radii.

1.6.5 EXTRATROPICAL TRANSITION

When a tropical cyclone moves into the mid-latitudes, it often enters an environment that is detrimental to the maintenance of the tropical cyclone's structure and energy-producing mechanisms. The effects of cooler sea-surface temperatures, cooler and dryer environmental air, and strong vertical wind shear all act to convert the tropical cyclone into an extratropical cyclone. JTWC indicates this conversion process is occurring by stating the tropical cyclone is "becoming extratropical." JTWC will indicate the conversion is expected to be complete by stating the system has "become extratropical." When a tropical cyclone is forecast to become extratropical, JTWC coordinates the transfer of warning responsibility to the appropriate agency.

1.6.6 TRANSFER OF WARNING RESPONSIBILITY

JTWC coordinates the transfer of the Department of Defense (DOD) warning responsibility for tropical cyclones entering or exiting its AOR. For tropical cyclones crossing 180E longitude in the North and South

Pacific Oceans, JTWC coordinates with NAVPACMETOCCEN, Pearl Harbor, Hawaii.

1.6.7 ALTERNATE JOINT TYPHOON WARNING CENTER (AJTWC)

In the event that JTWC should become incapacitated, the Alternate Joint Typhoon Warning Center assumes JTWC's functions. AJTWC is located at Yokosuka, Japan. Assistance in determining satellite reconnaissance requirements, and in obtaining the resultant data, is provided by the Air Force Weather Agency (AFWA).